APPENDIX D

Preliminary Seismic Assessment

Prepared by GeoLogic Associates, August 2002

DRAFT
PRELIMINARY SEISMIC ASSESSMENT
ORANGE COUNTY DESALINATION PROJECT

HUNTINGTON BEACH
ORANGE COUNTY, CALIFORNIA

August, 2002

PREPARED FOR:

Poseidon Resources Corporation
3760 Kilroy Airport Way, Suite 260
Long Beach, California 90806

PREPARED BY:

GeoLogic Associates
1360 Valley Vista Drive
Diamond Bar, California 91765

DRAFT
PRELIMINARY SEISMIC ASSESSMENT
ORANGE COUNTY DESALINATION PROJECT
HUNTINGTON BEACH, CALIFORNIA

TABLE OF CONTENTS

1.0 INTRODUCTION

GeoLogic Associates (GLA) is pleased to present this report summarizing the results of our preliminary seismic assessment conducted at the Orange County Desalination Project site at the AES Generating Station in Huntington Beach, California. Poseidon Resources is interested in acquisition of all or part of the sites on which the decommissioned West, South and East fuel oil tanks are located (Plate 1). The purpose of the acquisition would be to construct a desalination facility and water storage reservoir.

The purpose of this report is to provide Poseidon Resources with a preliminary seismic assessment addressing the geologic, seismic and geotechnical constraints pertaining to the subject property, to aid the acquisition process. Specifically, the report presents the results of a fault investigation, liquefaction analysis and ground motion analysis, and makes general observations on foundation conditions. This report is based on literature sources and the field investigation described below, and incorporates the data and findings of a similar field investigation conducted by GLA in March 2002 for the West and the North tanks (GLA, 2002).

The site lies within the broadly defined Newport-Inglewood Fault Zone (NIFZ). The NIFZ is significant, first because it is the controlling source for seismic ground motions, and second, because of its potential for permanent ground deformation during earthquakes. Ground deformation includes liquefaction-induced ground movement, seismic settlement, and surface fault rupture. The investigation described below addresses these issues on a site specific basis utilizing subsurface information derived from conventional rotary borings and cone penetration tests (CPTs).

1.1 SCOPE OF WORK

The scope of work for this investigation included the following:

- Preparation of a health-and-safety plan for field investigation.
- Conducting eleven (11) CPTs.
- Drilling and logging four (4) mud rotary borings to characterize subsurface conditions and to verify and establish correlation with CPTs.
- Obtaining radiocarbon age dates for selected samples from the rotary borings.
- Conducting an evaluation of faulting based on stratigraphic correlations.
- Conducting a liquefaction analysis, and seismicity evaluation for the site to determine the characteristics of the maximum design earthquake.
- Preparation of a draft report summarizing the work completed for the project, incorporating data from a previous investigation at the site (GLA, 2002).

2.0 SITE DESCRIPTION

The subject property lies within the boundaries of the AES Generating Station located 1000 feet north of Pacific Coast Highway and west and south of the Huntington Beach flood control channel, in the southeast industrial area of Huntington Beach (Figure 1). The original area was marshland similar to the Talbert Marsh to the southeast. The decommissioned tanks are 40 feet in height, 200 feet in diameter and sit on raised fill pads approximately 4 feet above the surrounding grade at about elevation +10 feet (Plate 1). This elevation was achieved by placing approximately 10 feet of fill over the original site grade, which was near mean sea level. The tanks are surrounded by fill berms, now breached to allow access.

3.0 FIELD EXPLORATION

Field investigation consisted of drilling four borings to a depth of about 90 feet below ground surface (bgs) and advancing eleven CPTs to a depth of about 90 feet bgs. Location of these borings and CPTs are shown on Plate 1, along with the locations of borings and CPTs from the previous investigation of the site (GLA, 2002). Borings and CPTs have been numbered consecutively in order to facilitate data presentation and discussion. Thus, borings B1 and B2 from the previous investigation are followed by borings B3 through B6 from this investigation. Similarly, CPTs 1 through 10 from the previous investigation are followed by CPTs 11 through 21A.

Drilling was performed by Gregg Drilling, under the supervision of a Certified Engineering Geologist, using a mud-rotary rig with an 8-inch diameter bit. Continuous sampling over the length of the borings was accomplished by alternating undisturbed samples with Standard Penetration Tests (SPTs) in the first 50 feet bgs, and thereafter obtaining only undisturbed samples. Undisturbed samples were collected with a Pitcher Barrel sampler and shelby tubes. Samples were extruded from the tubes at the drill site and placed in core boxes. Bulk samples were collected from Standard Penetration Tests (SPTs), conducted in accordance with ASTM Test Method 1585-94. Logs of the borings from this and the previous investigation are presented in Appendix A.

Eleven CPTs were conducted by Gregg Drilling under supervision of a Certified Engineering Geologist, along two lines (Plate 1). Four tests were located along a line west of the South tank and seven along a line between the South tank and the East tank. The purpose of these tests was twofold: to investigate potential for ground rupture during an earthquake event associated with local faults; and to investigate subsurface soil conditions for geotechnical characterization. Location of the lines and specific CPTs were judiciously selected to complement the data obtained during the previous investigation for the West and the North tanks (GLA 2002). Interpretation of CPT data for assessment of ground rupture potential is discussed in Section 6. The CPTs were conducted by Gregg Drilling in accordance with ASTM standard procedure No. 3441-070, wherein the cone is advanced at a constant rate of 2 centimeters per second (approximately 1 inch per second), while the tip resistance and friction sleeve resistance were automatically recorded by an electronic data collection system. The soil types encountered were deduced by comparing the magnitudes of the tip resistance and the friction sleeve ratio. Graphic records of the CPT logs and interpreted data from this and the previous investigation are included in Appendix B.

4.0 LABORATORY TESTING

Radiocarbon dating was performed by Beta Analytic, Inc. on selected samples obtained from the rotary boreholes. Results of these analyses are presented in Table 1 along with radiocarbon dates from the previous site investigation.

5.0 GEOLOGIC SETTING

The site is located approximately 2,000 feet northeast of the mean sea level datum, scaled from the USGS 7.5 minute Newport Beach Quadrangle (Figure 1), and lies within a former estuarine environment. Groundwater varies between 7 feet and 10 feet below ground surface and is apparently influenced by tidal variation in real time. The area is impacted by seawater intrusion and the groundwater is saline.

The site occupies a central position on the Santa Ana River floodplain between Newport Mesa to the south and Huntington Beach Mesa to the north (Figure 2). At least several hundred feet of Quaternary sediments underlie the floodplain along the coastal strip, including approximately 80 feet of Holocene sediments at the location of the tank sites (see Section D-D', Plate 1). Mainly older deposits underlie the uplifted mesas. The site is located within the Newport-Inglewood fault zone (NIFZ), however, the immediate area features little natural topographic relief and no geologic structures are expressed at the ground surface.

The site stratigraphy is illustrated on Plate 1. Boreholes drilled to approximately 90 feet bgs encountered approximately 9 feet of fill, underlain by approximately 4 feet of soft estuarine clay. Below the clay is an interbedded sequence of dense to very dense sandy soils with varying quantities of marine shell fragments and thin layers of clay and silt. To a depth of approximately 72 feet the interbedded sequence is of marine or estuarine origin, below that depth the sequence is non-marine in origin. The non-marine/marine transition below the site represents the on-lap of rising sea level during the Holocene epoch. Materials for C14 age dating, shells from the marine section, carbon from the non-marine section, were collected from the drilled samples. The age determinations and stratigraphy are shown on Plate 1 and discussed in Section 6.0.

6.0 FAULT INVESTIGATION

The NIFZ is a broad zone of deformation comprised of several known, or inferred, fault segments and secondary structures that extends from the Santa Monica Mountains to the off shore zone south of Newport (Grant and others, 1997). Locally, a portion of the NIFZ in Huntington Beach (North Branch Fault) is included in an Alquist-Priolo (A-P) fault hazard zone, signifying evidence of surface fault rupture in the last 11,000 years. The project site is not included in the A-P zone. The most comprehensive evaluation of surface fault evidence in the area appears to be Bryant (1988), which indicates the North Branch fault lies northwest of the site, while the closest fault segment of the NIFZ is an inferred trace with no surface expression lying approximately 1000 feet northeast of the North tank site (Figure 2). This feature is known from oil well data and its location at the surface has not been confirmed. The existence of a south branch of the NIFZ has been postulated (e.g., Guptill and Heath, 1981), but there is little specific evidence cited for it. Bryant (1988) does not include a south branch fault in his summary.

6.1 METHODOLOGY

Conventional fault trenching and soil-stratigraphic techniques could not be employed at the site because of the depth of fill overlying native soils and shallow groundwater. In any case, conclusions from trenching would be limited by the young age of the shallow sediments. In lieu of trenching, an option consistent with the scope of the investigation was to employ stratigraphic correlation based on CPTs and borings to locate subsurface discontinuities in marker beds indicative of faulting. The nature of the site stratigraphy (i.e., relatively flat lying Holocene strata) lends itself to this technique. The use of CPTs as high-resolution stratigraphic logging tools, together with conventional borings to confirm soil types and collect material for radiocarbon dating, have proven useful in constraining the location and age of probable fault structures on the North Branch fault (Grant and others, 1997). The study location of Grant and others (1997) is shown on Figure 2.

As indicated on Plate 1, CPTs were deployed along three northeast oriented transects. The orientation of these lines anticipates crossing fault structures on northwest trends (see Figure 2) and provides nearly complete coverage of site between the locations of the southwest-most and northeast-most CPT locations. In addition, six rotary boreholes were drilled in proximity to the CPT transects to provide samples and visual confirmation of soil types. The analysis of the resulting data followed the general approach described in Grant, and others (1997).

6.2 FINDINGS

Stratigraphic profiles AA', BB', and CC' are shown on Plate 1. The profiles depict correlation between CPT and calibrated boring logs.

The main features of the stratigraphy revealed in borings B1 through B6 are similar. Below the fill layer the section comprises littoral and estuarine deposits overlying fluvial deposits. The apparent transition occurs at approximate elevation –60 along Profiles BB' and CC' (base of marker unit F6), and defines an unconformable surface between non-marine deposits below and marine deposits above. This surface is interpreted as the floodplain of the Santa Ana River graded to the rising sea level of the Holocene. Littoral deposits consist of relatively uniform fine-grained sand and interbedded silty sand with locally

locally abundant shells. Density contrasts are apparent in the littoral sands, but little variety in soil type was noted in the boring logs. Estuarine deposits form thin plastic clay and silt layers interbedded with the marine sands. These deposits contain shells and organic matter and may represent still-stands in the rising Holocene sea level. The fluvial deposits consist of sand, silt and clay containing plant material, fragmental carbon, and absent marine shells.

Ten fine grained marker units were identified on the stratigraphic profiles. Marker units were designated as those beds or lenses that could be correlated in sequence through three or more CPTs or borings. The stratigraphic sequence defined by the marker units is readily apparent throughout Stratigraphic Profiles BB' and CC' (Plate 1). The sequence in Stratigraphic Profile AA', however, below the marine/non-marine transition, is less certain. This variation is interpreted as in part the result of lateral facies changes, perhaps the result of deposition within paleochannels, and in part the effect of an angular unconformity below the littoral section. In boring B2, the marker unit F6, which elsewhere marks the base of the estuarine and littoral section is absent. Nonetheless, the chronologic sequence determined in B2 and Profile AA' is consistent with the sequence in determined for Profiles BB' and CC' (Plate 1).

Radiocarbon and calibrated ages shown in Table 1, and plotted on the profiles, are in temporal order with respect to stratigraphic position. Calibrated ages indicate the drilled section represents a period greater than 12,000 years before present (ybp), the whole of Holocene time is generally taken as 11,000 ybp. Deposition of the littoral and estuarine soils occurred between modern time and about 8,000+ ybp. Comparison of the elevation of the dated samples with sea level at corresponding times suggest a depositional history similar to that described in Grant and others (1997, Figure 5), and suggests the marine on-lap occurred about 8,600 ybp at the project location.

TABLE 1
RADIOCARBON DATES

Ref. No.	Sample	Beta No.	Depth Ft, bgs	Elevation Ft	Radiocarbon Age, BP	Calibrated Age, BP	2 Sigma Error BP
1	B2-12	166268	17.5	-7.4	2330+-50	1940	2060-1820
2	B6-27	169351	27	-17	4390+-80	4520	4800-4340
3	B2-28	166269	41.5	-31.4	6570+-60	7090	7230-6930
4	B4-55	169352	53.5	-44.9	7210+-60	7660	7780-7570
5	B2-48	166270	71	-60.9	7610+- 50	8040	8160-7950
6	B2-49	166272	73	-62.9	8590+-100	9540	9860-9450
7	B6-76	169354	76	-66	8630+-50	9550	9700-9520
8	B4-81	169355	81	-72.4	9980+-60	11320	11650-11220
9	B1-55	166271	83.5	-74.4	10310+-70	12120	12780-11840

Table 2 summarizes marker unit age and correlation between profiles.

TABLE 2
CORRELATION & AGE OF MARKER UNITS

Marker Unit	Profile AA'	Profile BB'	Profile CC"	Approx. Age, ybp
F1	X	X	X	
F2	X	X	X	<1900
F3			X	4500
F3'	X			<7100
F4	X	X	X	7600
F5			X	
F6	X(?)	X	X	8600
F7	X(?)	X	X	9500
F8		X		
F9	X(?)	X	X	12000

6.3 GROUND RUPTURE RISK

The stratigraphic relationships represented by Statigraphic Profiles BB' and CC' are internally consistent and provide no evidence of fault disruption in the section. The systematic pattern of offsets (i.e., progressively greater vertical displacement of units with increasing depth), observed by Grant and others (1997) as the defining criteria for vertical fault offset on the North Branch fault, were not apparent in this study. Variations in elevation of the stratigraphic markers either are not systematic, or they are accounted for by the initial dip of the section and variation in lateral thickness. Profile AA' was not used in this assessment because the stratigraphic sequence below marker unit F4 could not be well established. With respect to evaluating potentially crossing faults on northwest trends, however, Profile AA' is not required because of the overlap in coverage provided by the other profiles.

Because the age of the stratigraphic section below the tank sites as determined by radiocarbon dating includes all of Holocene time, the absence of evidence of faulting, suggests the risk of future surface faulting a the site is a relative minimum.

7.0 SEISMIC ASSESSMENT

7.1 REGIONAL AND LOCAL SEISMIC SOURCES

Significant regional faults and historic seismicity, within a radius of 60 miles (100 km) of the tank sites, are shown in Figure 6. The NIFZ is closest active fault at a distance of less than one mile, therefore it dominates seismic exposure of the sites. Other significant active faults include Compton Thrust at a distance of about 6 miles, the Palos Verdes fault at about 11 miles, and the Elysian Park Thrust at about 14 miles. A more complete list of known active faults within a radius of 60 miles (100 km) of the sites is included in Appendix E.

7.2 EARTHQUAKE PARAMETERS

Earthquakes occurring within 60 miles (100 km) of the site can generate ground accelerations capable of damaging structures and inducing ground liquefaction. Using the California Division of Mines and Geology (CDMG) Open File Report (OFR) 96-08 (an extensive list of all known active faults in the State of California), both deterministic and probabilistic analyses of potential seismic hazards at the site were completed. The deterministic evaluation was based on the available information about historic seismicity for the recognized active faults within 60 miles (100 km) of the sites. This evaluation was done using computer programs EQSEARCH (Blake, 1996) and EQFAULT (Blake, 1998). Probabilistic evaluation was based on information about recurrence rates of earthquakes on these faults. Estimates of the maximum considered earthquake, with a probability of occurrence of 2 percent in 50 years, and the maximum probable earthquake (MPE), with a probability of occurrence of 10 percent in 50 years were made (as recommended in the Guidance for California Accidental Release Prevention Program- Seismic Assessment). Using this information and appropriate attenuation relationships, an estimate of the peak horizontal bedrock acceleration that might occur at the site was developed. Attenuation relationships developed by Abrahamson and Silva (1997) for soil site-condition were considered appropriate for this evaluation because these included near-field records for strong California earthquakes. Computer program FRISKSP (Blake, 1998) was used for this evaluation. Computer out-puts are presented in Appendix E.

For the tank sites, the available information on historic seismicity (included in Appendix E as an output of EQSEARCH program) indicates that in the past 200 years, the site may have experience an estimated maximum ground acceleration of 0.52 g during the March 11, 1933 Long Beach M6.3 earthquake at an epicentral distance of about 2 miles. Deterministic evaluation also indicates the maximum ground acceleration with a return period of 100 years to be about 0.327 g associated with a magnitude 5.8 earthquake on the Compton Thrust at about 6 miles from the site. An earthquake of magnitude 6.9 on the Newport Inglewood fault was considered to be the Maximum Credible Earthquake for the sites. For this event the maximum ground acceleration was determined to be about 0.535g.

Probabilistic evaluation of the seismic exposure of the site indicated that, for a Maximum Probable Earthquake (MPE), defined for the project as an event with a probability of occurrence of 10 percent in 50 years (or a return period of 475 years), the estimated maximum ground acceleration is about 0.39 g. The Maximum Considered Earthquake for project was defined as an event with a probability of occurrence of 2 percent in 50 years (or a return period of 2475 years). For this earthquake, the maximum bed rock acceleration at the site was estimated to be about 0.67g (see Appendix F). Since the estimated maximum acceleration for the Maximum Considered Earthquake exceeds that estimated for the Maximum Credible Earthquake on the Newport Inglewood fault, the maximum ground acceleration of 0.535 g was used for the MCE in this evaluation.

7.3 POTENTIAL FOR LIQUEFACTION

The site lies within zones identified on CDMG Seismic Hazards Zones Maps as "areas where historic occurrence of liquefaction, or local geologic, geotechnical and groundwater conditions indicate a potential for permanent ground displacements such that mitigation would be required".

Evaluation for liquefaction potential was made using the simplified procedure initially suggested by Seed and Idriss (1982) and described in the Proceedings of NCEER Workshop on Evaluation of Liquefaction Resistance of Soils (1997). The procedure involves comparing the induced cyclic stresses in the soil during the design earthquake to those required to induce liquefaction in the similar soils during similar earthquakes in the past. In the procedure the cyclic stresses induced by the earthquake are determined based on the maximum equivalent acceleration induced in the soil layer during the design earthquake and cyclic stress required to induce liquefaction is determined based on the observed behavior of similar soils that have and have not experienced liquefaction during an earthquake similar to the design earthquake. Since the initial presentation of the procedure, it has been widely used in the industry and had undergone several refinements.

Liquefaction potential was evaluated at the location of CPTs conducted. The potential was evaluated in terms of the ratio of the cyclic stress required to induce liquefaction to the cyclic stress mobilized by the earthquake in the soil profile. A ratio of less than 1.0 indicates that liquefaction is likely, while a ratio greater than 1.0 indicates that it is unlikely. Because the estimated maximum ground acceleration for the MPE (0.525 g based on historic seismicity) was only slightly lower than that for the Maximum Credible Earthquake (0.535 g associated with a maximum credible earthquake on the Newport-Inglewood fault), we have used 0.535 g as the maximum ground acceleration for the liquefaction evaluation. Groundwater was assumed at a depth of 7 feet below ground surface for this evaluation. Results of this evaluation are presented in Appendix F.

The liquefaction evaluation indicates that loose to medium dense sandy and silty-sandy soil layers encountered at depths of 7 to16 feet below ground surface at the site are susceptible to liquefaction during the postulated earthquake. Soils below that depth were not found to be susceptible to liquefaction. It is noted however, that the soil layers susceptible to liquefaction, although located in a small depth interval, were not determined to be continuous throughout the site. It is anticipated the liquefied soils may experience post-liquefaction settlements of 4 to 5 inches. It is further noted that because the zone of liquefiable soils was observed in most of the CPT locations the post-liquefaction settlements will likely be uniform through out the site.

7.4 SITE RESPONSE SPECTRA

For developing a UBC (1997) design response spectra, soil profile type S_D was used for the project site. The following parameters were used in developing the spectra:

Seismic Coefficient, C_a	$0.44N_a$
Seismic Coefficient, C_v	$0.64N_v$
Near Source Factor, N_a	1.3
Near Source Factor, N_v	1.6

The UBC spectra for the MPE ands MCE are presented in Figure 4.

7.5 POTENTIAL FOR TSUNAMIS/SEICHES

Historically, Southern California has been little affected by tsunamis (and by association, seiches). Distant tsunamis generated in the Gulf of Alaska or elsewhere on the Pacific Rim have not created significant tidal effects south of Point Arguello. Local tsunamis generated in the Santa Barbara Channel have occurred and produced small to moderate tidal effects along the south-facing coast between Santa Barbara and Ventura. None of these tsunamis, however, have had a measurable effect on the coastal structures in the vicinity of the AES Generating Station. To our knowledge, no historic tsunamis are recorded south of the Channel Islands.

The subject of current research is the tsunami potential posed by northwest trending offshore faults, such as the San Clemente Fault, Palos Verdes Fault, and the offshore segment of the Newport-Inglewood-Rose Canyon Fault (e.g., Legg and Borrero, 2001). Modeling of tsunami events located on the San Clemente Fault, for example, suggests that seafloor displacements of about 2 meters, associated with earthquakes of magnitude 7 or greater, would be required to produce a wave run-up of about 2 meters off the San Diego-Ensenada coast. This result suggests, in turn, that we may associate the frequency of tsunamis with the return period of very large earthquakes on the offshore faults. The maximum credible earthquake associated with these faults is between about M7 to M7.4 (the magnitudes required for tsunami generation), thus, likely return periods would be on the order of 500 years to greater than 1000 years (compared to the 50-year design life of the desalination facility). Maximum probable earthquakes (100-year events) estimated for these faults are between M6 to M6.5, below the probable threshold for tsunami generation.

Although the results of this research indicate that the offshore faults are demonstrably active and have at least a theoretical potential to generate tsunamis, historic seismic activity along these faults has not created measurable tsunami effects in the vicinity of the power plant nor seiche waves in the Huntington Beach Channel. The design basis earthquake is unlikely to generate tsunamis or seiches.

In addition, site-specific attributes of the proposed desalination plant site minimize the actual risks posed by tsunamis and seiches. First, the existing grade of the site lies at about 10 feet above mean sea level. Second, the site is surrounded by 12-foot high containment berms, which would serve as protective berms. Third, levees along the Huntington Beach Channel adjacent to the project site would mitigate potential seiche effects in the channel.

8.0 CONCLUSIONS

The investigation did not find evidence of faulting at the site. We conclude that the risk of surface fault rupture is minimal over the lifetime of the proposed project. The site may be subject to moderate liquefaction effects to a depth of about 16 feet, and only minor and apparently isolated effects at deeper depths. Foundation conditions are similar to those reported for the West and North Tanks (GLA, 2002), which include compressible soils to a depth of about ten to fifteen feet.

9.0 LIMITATIONS AND CLOSURE

This report has been prepared based on available data and limited field observations, which represent only a small sampling of subsurface conditions. The conclusions derived herein are based on the assumption that these conditions do not deviate appreciably from those found during this and previous investigations. Further, this report has been prepared in accordance with generally accepted geotechnical and geologic practices and is intended for planning and design purposes only. Professional judgements represented herein are based on our evaluations of the technical information gathered, on our general understanding of the proposed project, and on our general experience. We do not guarantee the performance of the project in any respect. It is recommended that GLA review future relevant documents to verify that the intent of the conclusions presented herein have been properly interpreted.

Geo Logic Associates,

Kent McMillan, Ph.D., CEG 1152
Principal Geologist

Jagdish Mathur, Ph.D., GE 568
Supervising Geotechnical Engineer

Bill Lopez, CEG 2143
Project Engineering Geologist

10.0 REFERENCES

Bryant, W.A. (1988), Recently Active Traces of the Newport-Inglewood Fault Zone, Los Angeles and Orange Counties, California, CDMG Open-File Report 88-14.

Grant, L.B., Waggoner, J.T., Rockwell, T.K., and von Stein, C. (1997), Paleoseismicity of the North Branch of the Newport-Inglewood Fault Zone in Huntington Beach, California, from cone penetrometer test data, BSSA, vol. 87, No. 2, pp. 277-293.

Blake, Thomas F., 1996, "EQSEARCH-Version 2.20, A Computer Program for the Estimation of Peak Horizontal Acceleration from California Historical Earthquake Catalogs", Computer Services and Software, Newbury, Calif., January.

Blake, Thomas F., 1998, "EQFAULT- Version 2.20, A Computer Program for the Deterministic Predication of Peak Horizontal Acceleration From Digitized California Faults", Computer Services and Software, Newbury, Calif., January.

Blake, Thomas F., 1998, "FRISKSP- Version 3.01B, A Computer Program for the Probabilistic Estimation of Seismic Hazard Using Faults as Earthquake Sources", Computer Services and Software, Newbury, Calif., July.

CDMG, 1997, Guidelines for Evaluating and Mitigating Seismic Hazards in California, California Division of Mines and Geology, Special Publication, 117, 74p.

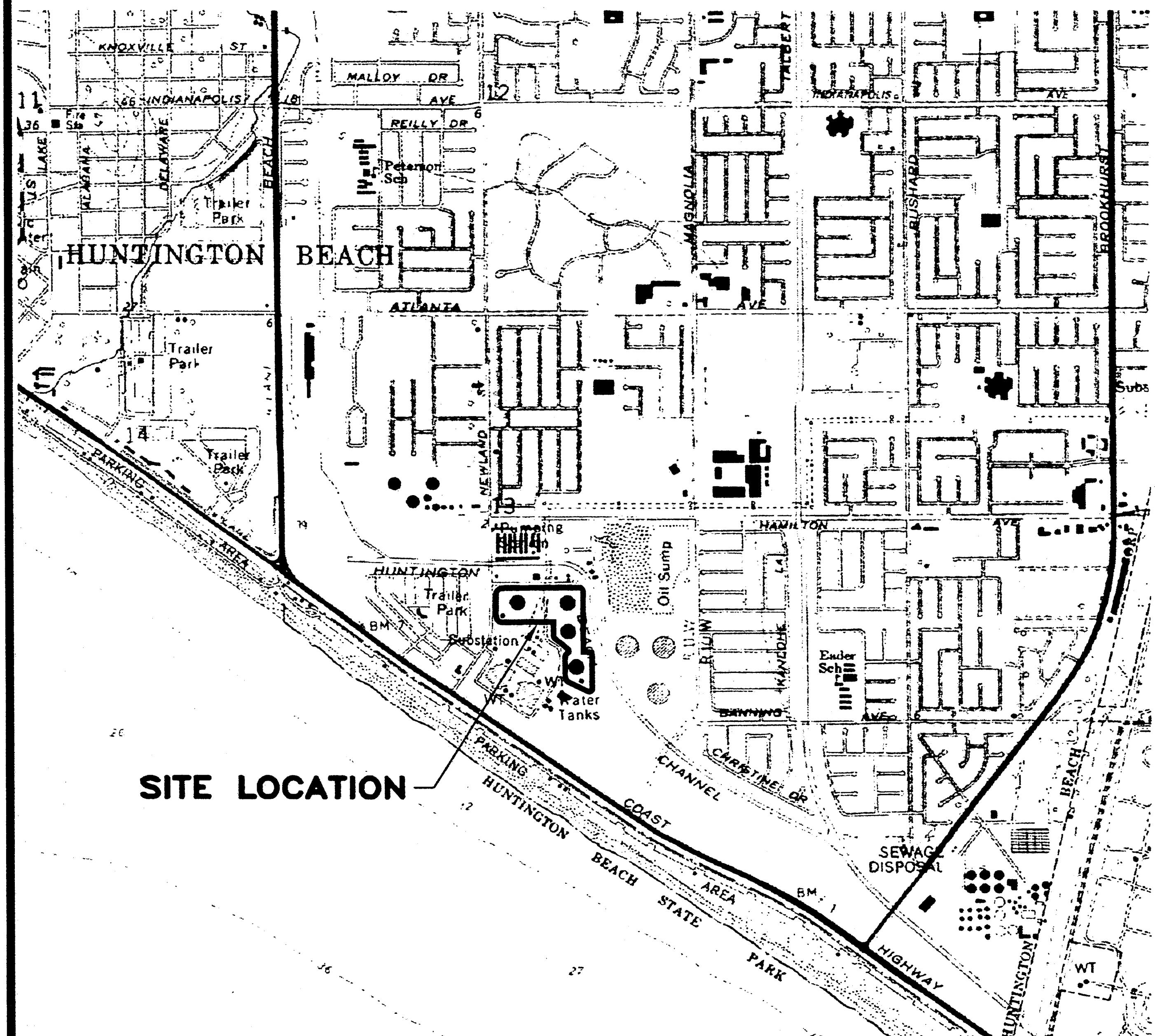
GLA, 2002, "Preliminary Geotechnical Assessment, Southeast Reservoir Site Acquisition, Huntington Beach, California", Prepared for Public Works Department, City of Huntington Beach, California, May 24, 2002.

Legg, M.R., and Borrero, J.C., 2001, Tsunami potential of major restraining bends along submarine strike-slip faults: in Proc. International Tsunami Symposium 2001, NOAA/PMEL, Seattle, WA, p. 331-342.

Seed, H.B., I. M. Idriss, 1982, "Ground Motions and Soil Liquefaction During Earthquakes," Earthquake Engineering Research Institute Monograph.

Wright, T.L. (1991), Structural geology and tectonic evolution of the Los Angeles basin, in Active Margin Basins, K.T. Biddie (ed.), Am. Assoc. Petrol. Geol. Mem. 52, pp. 35-134.

FIGURES



REFERENCE: USGS 7.5 MINUTE SERIES (TOPOGRAPHIC) NEWPORT BEACH, CALIFORNIA QUADRANGLE, 1981

APPROXIMATE SCALE: 1" = 2,000'

N

FIGURE 1

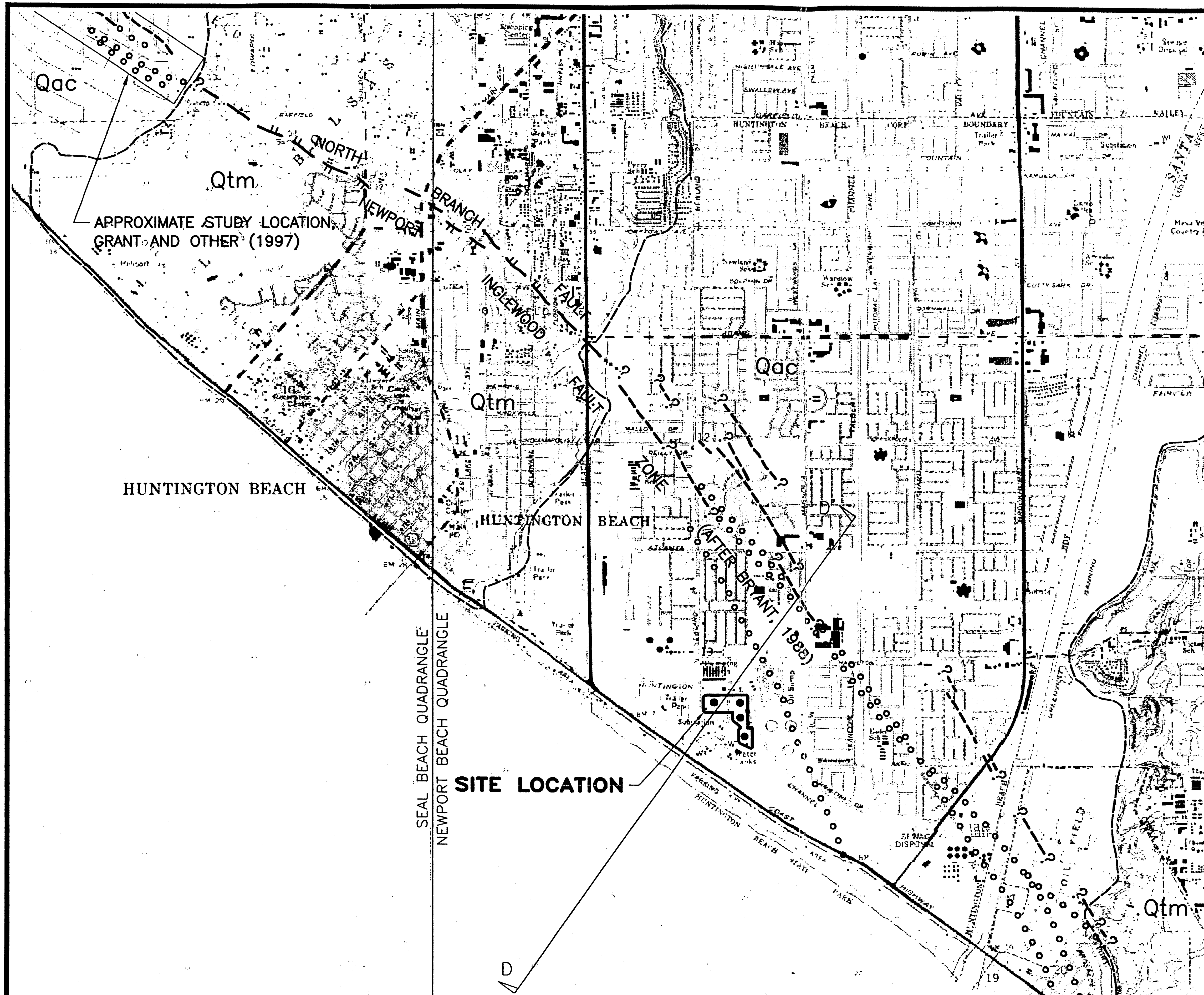
SITE LOCATION MAP

PRELIMINARY SEISMIC ASSESSMENT
ORANGE COUNTY DESALINATION PROJECT
HUNGTINGTON BEACH, CALIFORNIA

GeoLogic Associates
Geologists, Hydrogeologists, and Engineers

DRAWN BY:	DATE:	JOB NO.
VL	AUGUST 2002	2002-050

INTENTIONALLY LEFT BLANK



EXPLANATION:

Qac ALLUVIUM AND ESTUARINE DEPOSITS

Qtm MARINE TERRACE DEPOSITS

APPROXIMATE GEOLOGIC CONTACT

TRACES OF RECENTLY ACTIVE FAULTS. SOLID LINE INDICATES WELL-DEFINED FEATURE; LONG DASH WHERE APPROXIMATELY LOCATED; SHORT DASH WHERE INFERRED; DOTTED LINE WHERE CONCEALED; QUERRIES INDICATE UNCERTAINTY; HATCHURES INDICATE DIRECTIONS SCARP FACES.

FAULT IN SUBSURFACE INTERPRETED FROM OIL WELL DATA. THESE FAULTS, WHICH PRESUMABLY OFFSET ALL LITHOLOGIC UNITS, ARE SHOWN AT DEPTH OF CONTOURED HORIZON.

D D' LOCATION OF GEOLOGIC CROSS-SECTION

REFERENCE:

USGS 7.5 MINUTE SERIES (TOPOGRAPHIC) NEWPORT BEACH AND SEAL BEACH, CALIFORNIA QUADRANGLES (1981)

FAULT LOCATIONS FROM BRYANT (1988)

GEOLOGY FROM MORTON AND MILLER (1981)

N

APPROXIMATE SCALE: 1" = 2,500'

FIGURE 2

LOCAL FAULT MAP

PRELIMINARY SEISMIC ASSESSMENT
ORANGE COUNTY DESALINATION PROJECT
HUNGTINGTON BEACH, CALIFORNIA

GeoLogic Associates
Geologists, Hydrogeologists, and Engineers

DRAWN BY:	DATE:	JOB NO.
VL	AUGUST 2002	2002-050

INTENTIONALLY LEFT BLANK

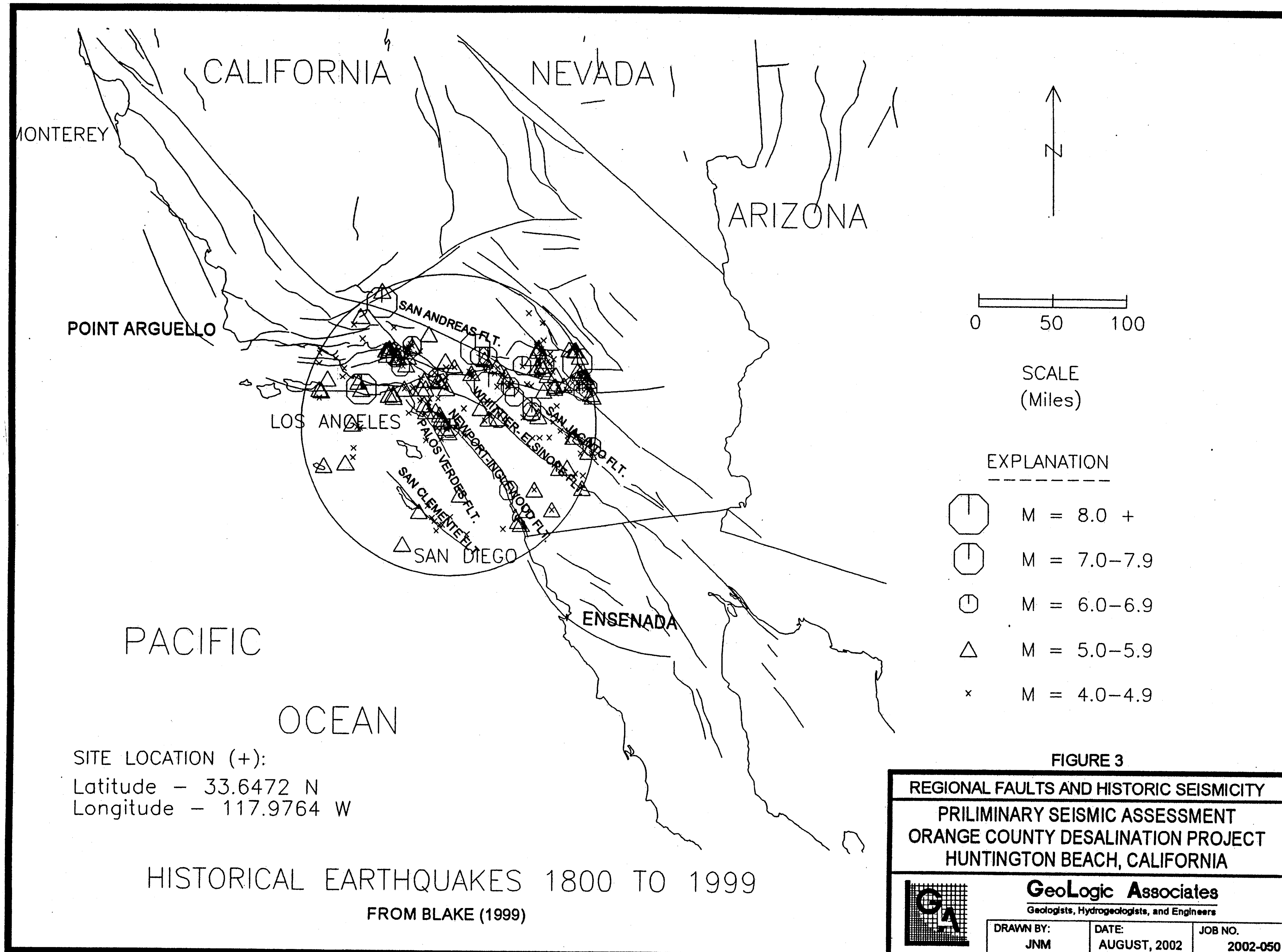


FIGURE 3

REGIONAL FAULTS AND HISTORIC SEISMICITY

PRILIMINARY SEISMIC ASSESSMENT
ORANGE COUNTY DESALINATION PROJECT
HUNTINGTON BEACH, CALIFORNIA

GeoLogic Associates
Geologists, Hydrogeologists, and Engineers

DRAWN BY:	DATE:	JOB NO.
JNM	AUGUST, 2002	2002-050

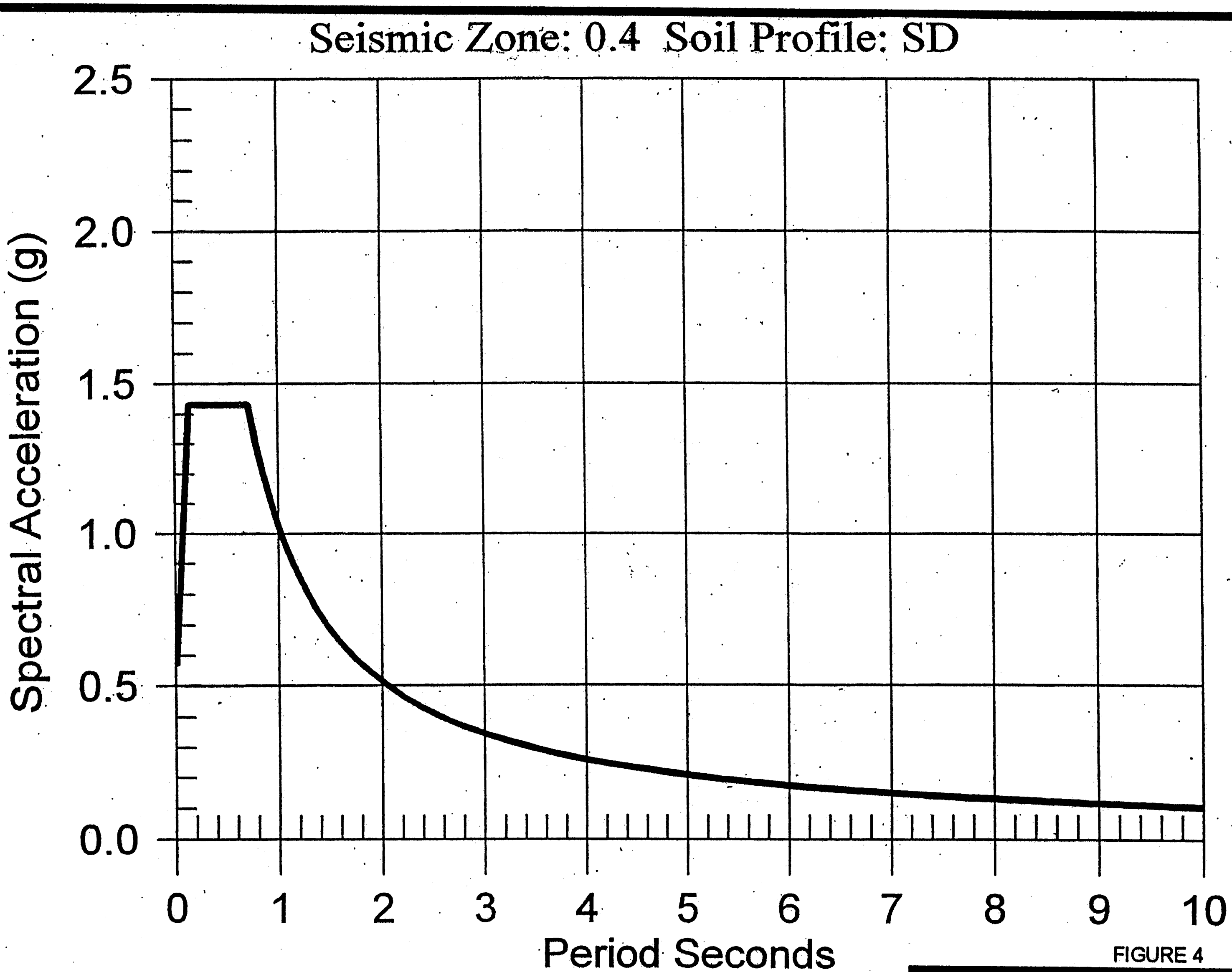


FIGURE 4

UBC DESIGN RESPONSE SPECTRUM
PRILIMINARY SESISMIC ASSESSMENT ORANGE COUNTY DESALINATION PROJECT HUNTINGTON BEACH, CALIFORNIA
GeoLogic Associates Geologists, Hydrogeologists, and Engineers

DRAWN BY:	DATE:	JOB NO.
JNM	AUGUST, 2002	2002-050

The technical appendices to the Draft Preliminary Seismic Assessment, Orange County Desalination Project are available for review at the City of Huntington Beach Planning Department, 2000 Main Street, Huntington Beach, CA, 92648.

INTENTIONALLY LEFT BLANK

DRAFT
PRELIMINARY SEISMIC ASSESSMENT
ORANGE COUNTY DESALINATION PROJECT

HUNTINGTON BEACH

ORANGE COUNTY, CALIFORNIA

August, 2002

DRAFT

PREPARED FOR:

Poseidon Resources Corporation
3760 Kilroy Airport Way, Suite 260
Long Beach, California 90806

PREPARED BY:

GeoLogic Associates
1360 Valley Vista Drive
Diamond Bar, California 91765

DRAFT
PRELIMINARY SEISMIC ASSESSMENT
ORANGE COUNTY DESALINATION PROJECT
HUNTINGTON BEACH, CALIFORNIA

TABLE OF CONTENTS

1.0 INTRODUCTION

GeoLogic Associates (GLA) is pleased to present this report summarizing the results of our preliminary seismic assessment conducted at the Orange County Desalination Project site at the AES Generating Station in Huntington Beach, California. Poseidon Resources is interested in acquisition of all or part of the sites on which the decommissioned West, South and East fuel oil tanks are located (Plate 1). The purpose of the acquisition would be to construct a desalination facility and water storage reservoir.

The purpose of this report is to provide Poseidon Resources with a preliminary seismic assessment addressing the geologic, seismic and geotechnical constraints pertaining to the subject property, to aid the acquisition process. Specifically, the report presents the results of a fault investigation, liquefaction analysis and ground motion analysis, and makes general observations on foundation conditions. This report is based on literature sources and the field investigation described below, and incorporates the data and findings of a similar field investigation conducted by GLA in March 2002 for the West and the North tanks (GLA, 2002).

The site lies within the broadly defined Newport-Inglewood Fault Zone (NIFZ). The NIFZ is significant, first because it is the controlling source for seismic ground motions, and second, because of its potential for permanent ground deformation during earthquakes. Ground deformation includes liquefaction-induced ground movement, seismic settlement, and surface fault rupture. The investigation described below addresses these issues on a site specific basis utilizing subsurface information derived from conventional rotary borings and cone penetration tests (CPTs).

1.1 SCOPE OF WORK

The scope of work for this investigation included the following:

- Preparation of a health-and-safety plan for field investigation.
- Conducting eleven (11) CPTs.
- Drilling and logging four (4) mud rotary borings to characterize subsurface conditions and to verify and establish correlation with CPTs.
- Obtaining radiocarbon age dates for selected samples from the rotary borings.
- Conducting an evaluation of faulting based on stratigraphic correlations.
- Conducting a liquefaction analysis, and seismicity evaluation for the site to determine the characteristics of the maximum design earthquake.
- Preparation of a draft report summarizing the work completed for the project, incorporating data from a previous investigation at the site (GLA, 2002).

2.0 SITE DESCRIPTION

The subject property lies within the boundaries of the AES Generating Station located 1000 feet north of Pacific Coast Highway and west and south of the Huntington Beach flood control channel, in the southeast industrial area of Huntington Beach (Figure 1). The original area was marshland similar to the Talbert Marsh to the southeast. The decommissioned tanks are 40 feet in height, 200 feet in diameter and sit on raised fill pads approximately 4 feet above the surrounding grade at about elevation +10 feet (Plate 1). This elevation was achieved by placing approximately 10 feet of fill over the original site grade, which was near mean sea level. The tanks are surrounded by fill berms, now breached to allow access.

3.0 FIELD EXPLORATION

Field investigation consisted of drilling four borings to a depth of about 90 feet below ground surface (bgs) and advancing eleven CPTs to a depth of about 90 feet bgs. Location of these borings and CPTs are shown on Plate 1, along with the locations of borings and CPTs from the previous investigation of the site (GLA, 2002). Borings and CPTs have been numbered consecutively in order to facilitate data presentation and discussion. Thus, borings B1 and B2 from the previous investigation are followed by borings B3 through B6 from this investigation. Similarly, CPTs 1 through 10 from the previous investigation are followed by CPTs 11 through 21A.

Drilling was performed by Gregg Drilling, under the supervision of a Certified Engineering Geologist, using a mud rotary rig with an 8-inch diameter bit. Continuous sampling over the length of the borings was accomplished by alternating undisturbed samples with Standard Penetration Tests (SPTs) in the first 50 feet bgs, and thereafter obtaining only undisturbed samples. Undisturbed samples were collected with a Pitcher Barrel sampler and shelby tubes. Samples were extruded from the tubes at the drill site and placed in core boxes. Bulk samples were collected from Standard Penetration Tests (SPTs), conducted in accordance with ASTM Test Method 1585-94. Logs of the borings from this and the previous investigation are presented in Appendix A.

Eleven CPTs were conducted by Gregg Drilling under supervision of a Certified Engineering Geologist, along two lines (Plate 1). Four tests were located along a line west of the South tank and seven along a line between the South tank and the East tank. The purpose of these tests was twofold: to investigate potential for ground rupture during an earthquake event associated with local faults; and to investigate subsurface soil conditions for geotechnical characterization. Location of the lines and specific CPTs were judiciously selected to complement the data obtained during the previous investigation for the West and the North tanks (GLA 2002). Interpretation of CPT data for assessment of ground rupture potential is discussed in Section 6. The CPTs were conducted by Gregg Drilling in accordance with ASTM standard procedure No. 3441-070, wherein the cone is advanced at a constant rate of 2 centimeters per second (approximately 1 inch per second), while the tip resistance and friction sleeve resistance were automatically recorded by an electronic data collection system. The soil types encountered were deduced by comparing the magnitudes of the tip resistance and the friction sleeve ratio. Graphic records of the CPT logs and interpreted data from this and the previous investigation are included in Appendix B.

4.0 LABORATORY TESTING

Radiocarbon dating was performed by Beta Analytic, Inc. on selected samples obtained from the rotary boreholes. Results of these analyses are presented in Table 1 along with radiocarbon dates from the previous site investigation.

5.0 GEOLOGIC SETTING

The site is located approximately 2,000 feet northeast of the mean sea level datum, scaled from the USGS 7.5 minute Newport Beach Quadrangle (Figure 1), and lies within a former estuarine environment. Groundwater varies between 7 feet and 10 feet below ground surface and is apparently influenced by tidal variation in real time. The area is impacted by seawater intrusion and the groundwater is saline.

The site occupies a central position on the Santa Ana River floodplain between Newport Mesa to the south and Huntington Beach Mesa to the north (Figure 2). At least several hundred feet of Quaternary sediments underlie the floodplain along the coastal strip, including approximately 80 feet of Holocene sediments at the location of the tank sites (see Section D-D', Plate 1). Mainly older deposits underlie the uplifted mesas. The site is located within the Newport-Inglewood fault zone (NIFZ), however, the immediate area features little natural topographic relief and no geologic structures are expressed at the ground surface.

The site stratigraphy is illustrated on Plate 1. Boreholes drilled to approximately 90 feet bgs encountered approximately 9 feet of fill, underlain by approximately 4 feet of soft estuarine clay. Below the clay is an interbedded sequence of dense to very dense sandy soils with varying quantities of marine shell fragments and thin layers of clay and silt. To a depth of approximately 72 feet the interbedded sequence is of marine or estuarine origin, below that depth the sequence is non-marine in origin. The non-marine/marine transition below the site represents the on-lap of rising sea level during the Holocene epoch. Materials for C14 age dating, shells from the marine section, carbon from the non-marine section, were collected from the drilled samples. The age determinations and stratigraphy are shown on Plate 1 and discussed in Section 6.0.

6.0 FAULT INVESTIGATION

The NIFZ is a broad zone of deformation comprised of several known, or inferred, fault segments and secondary structures that extends from the Santa Monica Mountains to the off shore zone south of Newport (Grant and others, 1997). Locally, a portion of the NIFZ in Huntington Beach (North Branch Fault) is included in an Alquist-Priolo (A-P) fault hazard zone, signifying evidence of surface fault rupture in the last 11,000 years. The project site is not included in the A-P zone. The most comprehensive evaluation of surface fault evidence in the area appears to be Bryant (1988), which indicates the North Branch fault lies northwest of the site, while the closest fault segment of the NIFZ is an inferred trace with no surface expression lying approximately 1000 feet northeast of the North tank site (Figure 2). This feature is known from oil well data and its location at the surface has not been confirmed. The existence of a south branch of the NIFZ has been postulated (e.g., Guptill and Heath, 1981), but there is little specific evidence cited for it. Bryant (1988) does not include a south branch fault in his summary.

6.1 METHODOLOGY

Conventional fault trenching and soil-stratigraphic techniques could not be employed at the site because of the depth of fill overlying native soils and shallow groundwater. In any case, conclusions from trenching would be limited by the young age of the shallow sediments. In lieu of trenching, an option consistent with the scope of the investigation was to employ stratigraphic correlation based on CPTs and borings to locate subsurface discontinuities in marker beds indicative of faulting. The nature of the site stratigraphy (i.e., relatively flat lying Holocene strata) lends itself to this technique. The use of CPTs as high-resolution stratigraphic logging tools, together with conventional borings to confirm soil types and collect material for radiocarbon dating, have proven useful in constraining the location and age of probable fault structures on the North Branch fault (Grant and others, 1997). The study location of Grant and others (1997) is shown on Figure 2.

As indicated on Plate 1, CPTs were deployed along three northeast oriented transects. The orientation of these lines anticipates crossing fault structures on northwest trends (see Figure 2) and provides nearly complete coverage of site between the locations of the southwest-most and northeast-most CPT locations. In addition, six rotary boreholes were drilled in proximity to the CPT transects to provide samples and visual confirmation of soil types. The analysis of the resulting data followed the general approach described in Grant, and others (1997).

6.2 FINDINGS

Stratigraphic profiles AA', BB', and CC' are shown on Plate 1. The profiles depict correlation between CPT and calibrated boring logs.

The main features of the stratigraphy revealed in borings B1 through B6 are similar. Below the fill layer the section comprises littoral and estuarine deposits overlying fluvial deposits. The apparent transition occurs at approximate elevation –60 along Profiles BB' and CC' (base of marker unit F6), and defines an unconformable surface between non-marine deposits below and marine deposits above. This surface is interpreted as the floodplain of the Santa Ana River graded to the rising sea level of the Holocene. Littoral deposits consist of relatively uniform fine-grained sand and interbedded silty sand with locally

locally abundant shells. Density contrasts are apparent in the littoral sands, but little variety in soil type was noted in the boring logs. Estuarine deposits form thin plastic clay and silt layers interbedded with the marine sands. These deposits contain shells and organic matter and may represent still-stands in the rising Holocene sea level. The fluvial deposits consist of sand, silt and clay containing plant material, fragmental carbon, and absent marine shells.

Ten fine grained marker units were identified on the stratigraphic profiles. Marker units were designated as those beds or lenses that could be correlated in sequence through three or more CPTs or borings. The stratigraphic sequence defined by the marker units is readily apparent throughout Stratigraphic Profiles BB' and CC' (Plate 1). The sequence in Stratigraphic Profile AA', however, below the marine/non-marine transition, is less certain. This variation is interpreted as in part the result of lateral facies changes, perhaps the result of deposition within paleochannels, and in part the effect of an angular unconformity below the littoral section. In boring B2, the marker unit F6, which elsewhere marks the base of the estuarine and littoral section is absent. Nonetheless, the chronologic sequence determined in B2 and Profile AA' is consistent with the sequence in determined for Profiles BB' and CC' (Plate 1).

Radiocarbon and calibrated ages shown in Table 1, and plotted on the profiles, are in temporal order with respect to stratigraphic position. Calibrated ages indicate the drilled section represents a period greater than 12,000 years before present (ybp), the whole of Holocene time is generally taken as 11,000 ybp. Deposition of the littoral and estuarine soils occurred between modern time and about 8,000+ ybp. Comparison of the elevation of the dated samples with sea level at corresponding times suggest a depositional history similar to that described in Grant and others (1997, Figure 5), and suggests the marine on-lap occurred about 8,600 ybp at the project location.

TABLE 1
RADIOCARBON DATES

Ref. No.	Sample	Beta No.	Depth Ft, bgs	Elevation Ft	Radiocarbon Age, BP	Calibrated Age, BP	2 Sigma Error BP
1	B2-12	166268	17.5	-7.4	2330+-50	1940	2060-1820
2	B6-27	169351	27	-17	4390+-80	4520	4800-4340
3	B2-28	166269	41.5	-31.4	6570+-60	7090	7230-6930
4	B4-55	169352	53.5	-44.9	7210+-60	7660	7780-7570
5	B2-48	166270	71	-60.9	7610+- 50	8040	8160-7950
6	B2-49	166272	73	-62.9	8590+-100	9540	9860-9450
7	B6-76	169354	76	-66	8630+-50	9550	9700-9520
8	B4-81	169355	81	-72.4	9980+-60	11320	11650-11220
9	B1-55	166271	83.5	-74.4	10310+-70	12120	12780-11840

Table 2 summarizes marker unit age and correlation between profiles.

TABLE 2
CORRELATION & AGE OF MARKER UNITS

Marker Unit	Profile AA'	Profile BB'	Profile CC"	Approx. Age, ybp
F1	X	X	X	
F2	X	X	X	<1900
F3			X	4500
F3'	X			<7100
F4	X	X	X	7600
F5			X	
F6	X(?)	X	X	8600
F7	X(?)	X	X	9500
F8		X		
F9	X(?)	X	X	12000

6.3 GROUND RUPTURE RISK

The stratigraphic relationships represented by Statigraphic Profiles BB' and CC' are internally consistent and provide no evidence of fault disruption in the section. The systematic pattern of offsets (i.e., progressively greater vertical displacement of units with increasing depth), observed by Grant and others (1997) as the defining criteria for vertical fault offset on the North Branch fault, were not apparent in this study. Variations in elevation of the stratigraphic markers either are not systematic, or they are accounted for by the initial dip of the section and variation in lateral thickness. Profile AA' was not used in this assessment because the stratigraphic sequence below marker unit F4 could not be well established. With respect to evaluating potentially crossing faults on northwest trends, however, Profile AA' is not required because of the overlap in coverage provided by the other profiles.

Because the age of the stratigraphic section below the tank sites as determined by radiocarbon dating includes all of Holocene time, the absence of evidence of faulting, suggests the risk of future surface faulting a the site is a relative minimum.

7.0 SEISMIC ASSESSMENT

7.1 REGIONAL AND LOCAL SEISMIC SOURCES

Significant regional faults and historic seismicity, within a radius of 60 miles (100 km) of the tank sites, are shown in Figure 6. The NIFZ is closest active fault at a distance of less than one mile, therefore it dominates seismic exposure of the sites. Other significant active faults include Compton Thrust at a distance of about 6 miles, the Palos Verdes fault at about 11 miles, and the Elysian Park Thrust at about 14 miles. A more complete list of known active faults within a radius of 60 miles (100 km) of the sites is included in Appendix E.

7.2 EARTHQUAKE PARAMETERS

Earthquakes occurring within 60 miles (100 km) of the site can generate ground accelerations capable of damaging structures and inducing ground liquefaction. Using the California Division of Mines and Geology (CDMG) Open File Report (OFR) 96-08 (an extensive list of all known active faults in the State of California), both deterministic and probabilistic analyses of potential seismic hazards at the site were completed. The deterministic evaluation was based on the available information about historic seismicity for the recognized active faults within 60 miles (100 km) of the sites. This evaluation was done using computer programs EQSEARCH (Blake, 1996) and EQFAULT (Blake, 1998). Probabilistic evaluation was based on information about recurrence rates of earthquakes on these faults. Estimates of the maximum considered earthquake, with a probability of occurrence of 2 percent in 50 years, and the maximum probable earthquake (MPE), with a probability of occurrence of 10 percent in 50 years were made (as recommended in the Guidance for California Accidental Release Prevention Program- Seismic Assessment). Using this information and appropriate attenuation relationships, an estimate of the peak horizontal bedrock acceleration that might occur at the site was developed. Attenuation relationships developed by Abrahamson and Silva (1997) for soil site-condition were considered appropriate for this evaluation because these included near-field records for strong California earthquakes. Computer program FRISKSP (Blake, 1998) was used for this evaluation. Computer out-puts are presented in Appendix E.

For the tank sites, the available information on historic seismicity (included in Appendix E as an output of EQSEARCH program) indicates that in the past 200 years, the site may have experience an estimated maximum ground acceleration of 0.52 g during the March 11, 1933 Long Beach M6.3 earthquake at an epicentral distance of about 2 miles. Deterministic evaluation also indicates the maximum ground acceleration with a return period of 100 years to be about 0.327 g associated with a magnitude 5.8 earthquake on the Compton Thrust at about 6 miles from the site. An earthquake of magnitude 6.9 on the Newport Inglewood fault was considered to be the Maximum Credible Earthquake for the sites. For this event the maximum ground acceleration was determined to be about 0.535g.

Probabilistic evaluation of the seismic exposure of the site indicated that, for a Maximum Probable Earthquake (MPE), defined for the project as an event with a probability of occurrence of 10 percent in 50 years (or a return period of 475 years), the estimated maximum ground acceleration is about 0.39 g. The Maximum Considered Earthquake for project was defined as an event with a probability of occurrence of 2 percent in 50 years (or a return period of 2475 years). For this earthquake, the maximum bed rock acceleration at the site was estimated to be about 0.67g (see Appendix F). Since the estimated maximum acceleration for the Maximum Considered Earthquake exceeds that estimated for the Maximum Credible Earthquake on the Newport Inglewood fault, the maximum ground acceleration of 0.535 g was used for the MCE in this evaluation.

7.3 POTENTIAL FOR LIQUEFACTION

The site lies within zones identified on CDMG Seismic Hazards Zones Maps as "areas where historic occurrence of liquefaction, or local geologic, geotechnical and groundwater conditions indicate a potential for permanent ground displacements such that mitigation would be required".

Evaluation for liquefaction potential was made using the simplified procedure initially suggested by Seed and Idriss (1982) and described in the Proceedings of NCEER Workshop on Evaluation of Liquefaction Resistance of Soils (1997). The procedure involves comparing the induced cyclic stresses in the soil during the design earthquake to those required to induce liquefaction in the similar soils during similar earthquakes in the past. In the procedure the cyclic stresses induced by the earthquake are determined based on the maximum equivalent acceleration induced in the soil layer during the design earthquake and cyclic stress required to induce liquefaction is determined based on the observed behavior of similar soils that have and have not experienced liquefaction during an earthquake similar to the design earthquake. Since the initial presentation of the procedure, it has been widely used in the industry and had undergone several refinements.

Liquefaction potential was evaluated at the location of CPTs conducted. The potential was evaluated in terms of the ratio of the cyclic stress required to induce liquefaction to the cyclic stress mobilized by the earthquake in the soil profile. A ratio of less than 1.0 indicates that liquefaction is likely, while a ratio greater than 1.0 indicates that it is unlikely. Because the estimated maximum ground acceleration for the MPE (0.525 g based on historic seismicity) was only slightly lower than that for the Maximum Credible Earthquake (0.535 g associated with a maximum credible earthquake on the Newport-Inglewood fault), we have used 0.535 g as the maximum ground acceleration for the liquefaction evaluation. Groundwater was assumed at a depth of 7 feet below ground surface for this evaluation. Results of this evaluation are presented in Appendix F.

The liquefaction evaluation indicates that loose to medium dense sandy and silty-sandy soil layers encountered at depths of 7 to16 feet below ground surface at the site are susceptible to liquefaction during the postulated earthquake. Soils below that depth were not found to be susceptible to liquefaction. It is noted however, that the soil layers susceptible to liquefaction, although located in a small depth interval, were not determined to be continuous throughout the site. It is anticipated the liquefied soils may experience post-liquefaction settlements of 4 to 5 inches. It is further noted that because the zone of liquefiable soils was observed in most of the CPT locations the post-liquefaction settlements will likely be uniform through out the site.

7.4 SITE RESPONSE SPECTRA

For developing a UBC (1997) design response spectra, soil profile type S_D was used for the project site. The following parameters were used in developing the spectra:

Seismic Coefficient, C_a	$0.44N_a$
Seismic Coefficient, C_v	$0.64N_v$
Near Source Factor, N_a	1.3
Near Source Factor, N_v	1.6

The UBC spectra for the MPE ands MCE are presented in Figure 4.

7.5 POTENTIAL FOR TSUNAMIS/SEICHES

Historically, Southern California has been little affected by tsunamis (and by association, seiches). Distant tsunamis generated in the Gulf of Alaska or elsewhere on the Pacific Rim have not created significant tidal effects south of Point Arguello. Local tsunamis generated in the Santa Barbara Channel have occurred and produced small to moderate tidal effects along the south-facing coast between Santa Barbara and Ventura. None of these tsunamis, however, have had a measurable effect on the coastal structures in the vicinity of the AES Generating Station. To our knowledge, no historic tsunamis are recorded south of the Channel Islands.

The subject of current research is the tsunami potential posed by northwest trending offshore faults, such as the San Clemente Fault, Palos Verdes Fault, and the offshore segment of the Newport-Inglewood-Rose Canyon Fault (e.g., Legg and Borrero, 2001). Modeling of tsunami events located on the San Clemente Fault, for example, suggests that seafloor displacements of about 2 meters, associated with earthquakes of magnitude 7 or greater, would be required to produce a wave run-up of about 2 meters off the San Diego-Ensenada coast. This result suggests, in turn, that we may associate the frequency of tsunamis with the return period of very large earthquakes on the offshore faults. The maximum credible earthquake associated with these faults is between about M7 to M7.4 (the magnitudes required for tsunami generation), thus, likely return periods would be on the order of 500 years to greater than 1000 years (compared to the 50-year design life of the desalination facility). Maximum probable earthquakes (100-year events) estimated for these faults are between M6 to M6.5, below the probable threshold for tsunami generation.

Although the results of this research indicate that the offshore faults are demonstrably active and have at least a theoretical potential to generate tsunamis, historic seismic activity along these faults has not created measurable tsunami effects in the vicinity of the power plant nor seiche waves in the Huntington Beach Channel. The design basis earthquake is unlikely to generate tsunamis or seiches.

In addition, site-specific attributes of the proposed desalination plant site minimize the actual risks posed by tsunamis and seiches. First, the existing grade of the site lies at about 10 feet above mean sea level. Second, the site is surrounded by 12-foot high containment berms, which would serve as protective berms. Third, levees along the Huntington Beach Channel adjacent to the project site would mitigate potential seiche effects in the channel.

8.0 CONCLUSIONS

The investigation did not find evidence of faulting at the site. We conclude that the risk of surface fault rupture is minimal over the lifetime of the proposed project. The site may be subject to moderate liquefaction effects to a depth of about 16 feet, and only minor and apparently isolated effects at deeper depths. Foundation conditions are similar to those reported for the West and North Tanks (GLA, 2002), which include compressible soils to a depth of about ten to fifteen feet.

9.0 LIMITATIONS AND CLOSURE

This report has been prepared based on available data and limited field observations, which represent only a small sampling of subsurface conditions. The conclusions derived herein are based on the assumption that these conditions do not deviate appreciably from those found during this and previous investigations. Further, this report has been prepared in accordance with generally accepted geotechnical and geologic practices and is intended for planning and design purposes only. Professional judgements represented herein are based on our evaluations of the technical information gathered, on our general understanding of the proposed project, and on our general experience. We do not guarantee the performance of the project in any respect. It is recommended that GLA review future relevant documents to verify that the intent of the conclusions presented herein have been properly interpreted.

Geo Logic Associates,

Kent McMillan, Ph.D., CEG 1152
Principal Geologist

Jagdish Mathur, Ph.D., GE 568
Supervising Geotechnical Engineer

Bill Lopez, CEG 2143
Project Engineering Geologist

10.0 REFERENCES

Bryant, W.A. (1988), Recently Active Traces of the Newport-Inglewood Fault Zone, Los Angeles and Orange Counties, California, CDMG Open-File Report 88-14.

Grant, L.B., Waggoner, J.T., Rockwell, T.K., and von Stein, C. (1997), Paleoseismicity of the North Branch of the Newport-Inglewood Fault Zone in Huntington Beach, California, from cone penetrometer test data, BSSA, vol. 87, No. 2, pp. 277-293.

Blake, Thomas F., 1996, "EQSEARCH-Version 2.20, A Computer Program for the Estimation of Peak Horizontal Acceleration from California Historical Earthquake Catalogs", Computer Services and Software, Newbury, Calif., January.

Blake, Thomas F., 1998, "EQFAULT- Version 2.20, A Computer Program for the Deterministic Predication of Peak Horizontal Acceleration From Digitized California Faults", Computer Services and Software, Newbury, Calif., January.

Blake, Thomas F., 1998, "FRISKSP- Version 3.01B, A Computer Program for the Probabilistic Estimation of Seismic Hazard Using Faults as Earthquake Sources", Computer Services and Software, Newbury, Calif., July.

CDMG, 1997, Guidelines for Evaluating and Mitigating Seismic Hazards in California, California Division of Mines and Geology, Special Publication, 117, 74p.

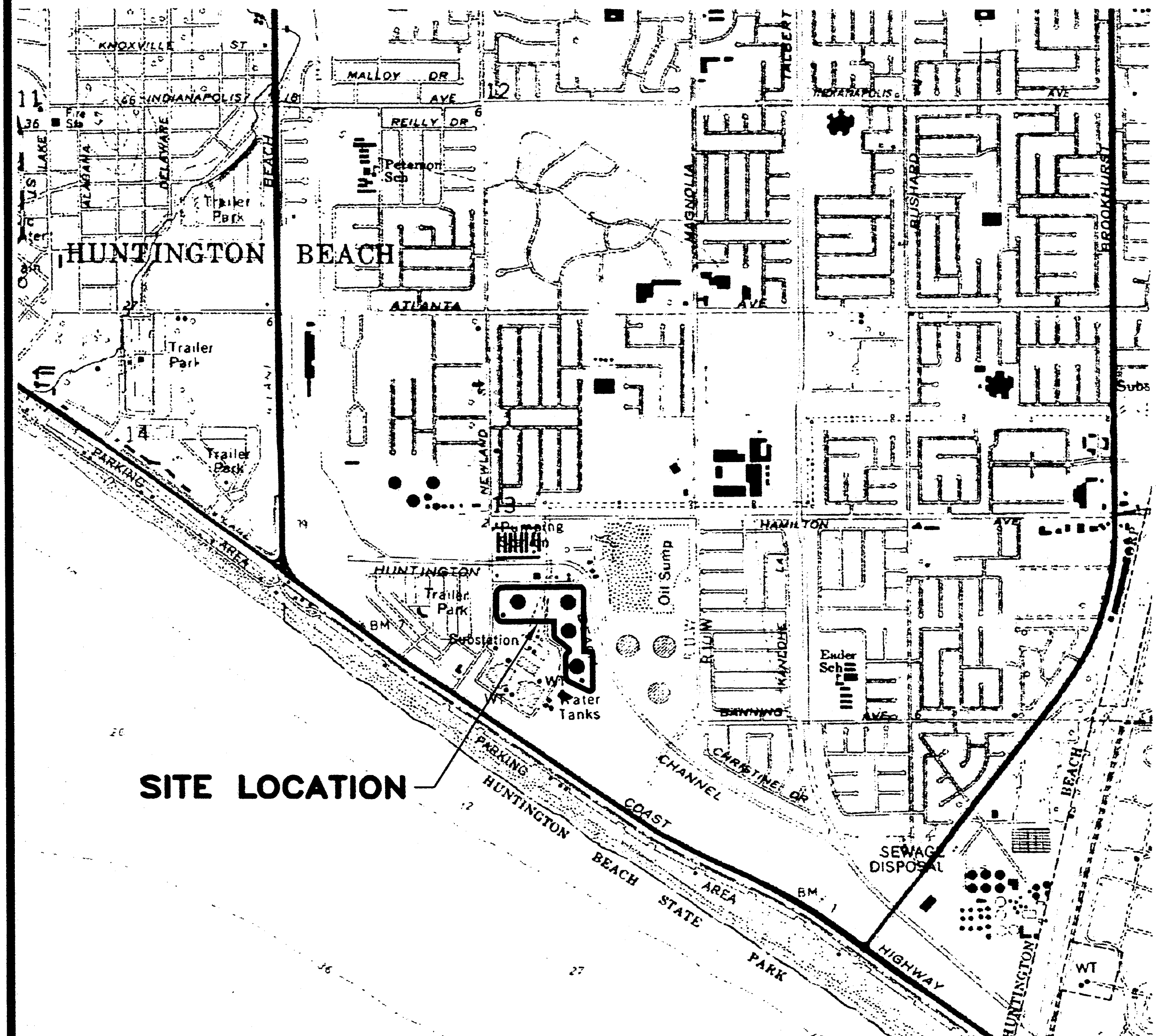
GLA, 2002, "Preliminary Geotechnical Assessment, Southeast Reservoir Site Acquisition, Huntington Beach, California", Prepared for Public Works Department, City of Huntington Beach, California, May 24, 2002.

Legg, M.R., and Borrero, J.C., 2001, Tsunami potential of major restraining bends along submarine strike-slip faults: in Proc. International Tsunami Symposium 2001, NOAA/PMEL, Seattle, WA, p. 331-342.

Seed, H.B., I. M. Idriss, 1982, "Ground Motions and Soil Liquefaction During Earthquakes," Earthquake Engineering Research Institute Monograph.

Wright, T.L. (1991), Structural geology and tectonic evolution of the Los Angeles basin, in Active Margin Basins, K.T. Biddie (ed.), Am. Assoc. Petrol. Geol. Mem. 52, pp. 35-134.

FIGURES



REFERENCE: USGS 7.5 MINUTE SERIES (TOPOGRAPHIC) NEWPORT BEACH, CALIFORNIA QUADRANGLE, 1981

FIGURE 1

SITE LOCATION MAP

PRELIMINARY SEISMIC ASSESSMENT
ORANGE COUNTY DESALINATION PROJECT
HUNGTINGTON BEACH, CALIFORNIA

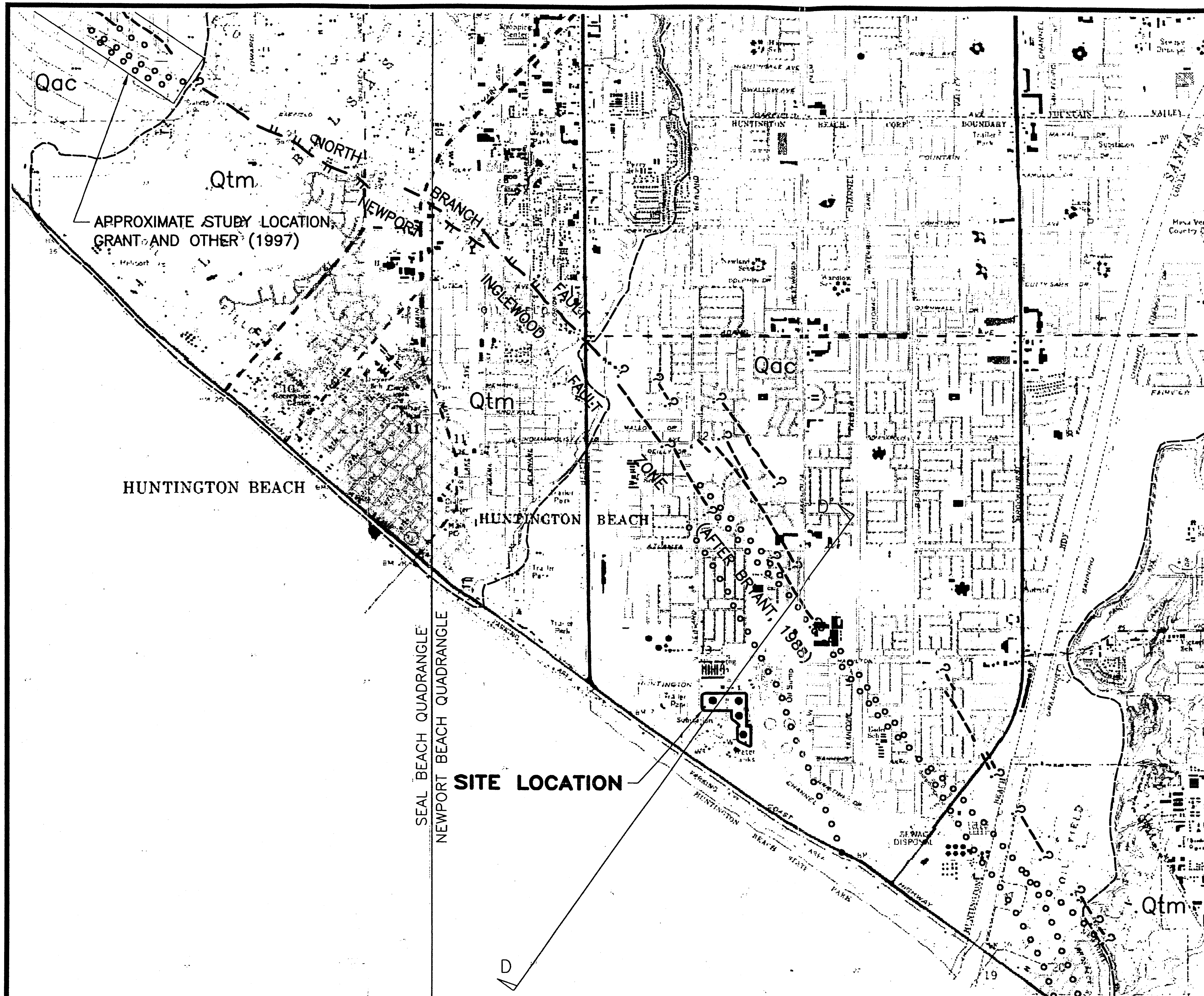
APPROXIMATE SCALE: 1" = 2,000'

N

GeoLogic Associates
Geologists, Hydrogeologists, and Engineers

DRAWN BY:	DATE:	JOB NO.
VL	AUGUST 2002	2002-050

INTENTIONALLY LEFT BLANK



EXPLANATION:

Qac ALLUVIUM AND ESTUARINE DEPOSITS

Qtm MARINE TERRACE DEPOSITS

APPROXIMATE GEOLOGIC CONTACT

TRACES OF RECENTLY ACTIVE FAULTS. SOLID LINE INDICATES WELL-DEFINED FEATURE; LONG DASH WHERE APPROXIMATELY LOCATED; SHORT DASH WHERE INFERRED; DOTTED LINE WHERE CONCEALED; QUERRIES INDICATE UNCERTAINTY; HATCHURES INDICATE DIRECTIONS SCARP FACES.

FAULT IN SUBSURFACE INTERPRETED FROM OIL WELL DATA. THESE FAULTS, WHICH PRESUMABLY OFFSET ALL LITHOLOGIC UNITS, ARE SHOWN AT DEPTH OF CONTOURED HORIZON.

D D' LOCATION OF GEOLOGIC CROSS-SECTION

REFERENCE:

USGS 7.5 MINUTE SERIES (TOPOGRAPHIC) NEWPORT BEACH AND SEAL BEACH, CALIFORNIA QUADRANGLES (1981)

FAULT LOCATIONS FROM BRYANT (1988)

GEOLOGY FROM MORTON AND MILLER (1981)

N

APPROXIMATE SCALE: 1" = 2,500'

FIGURE 2

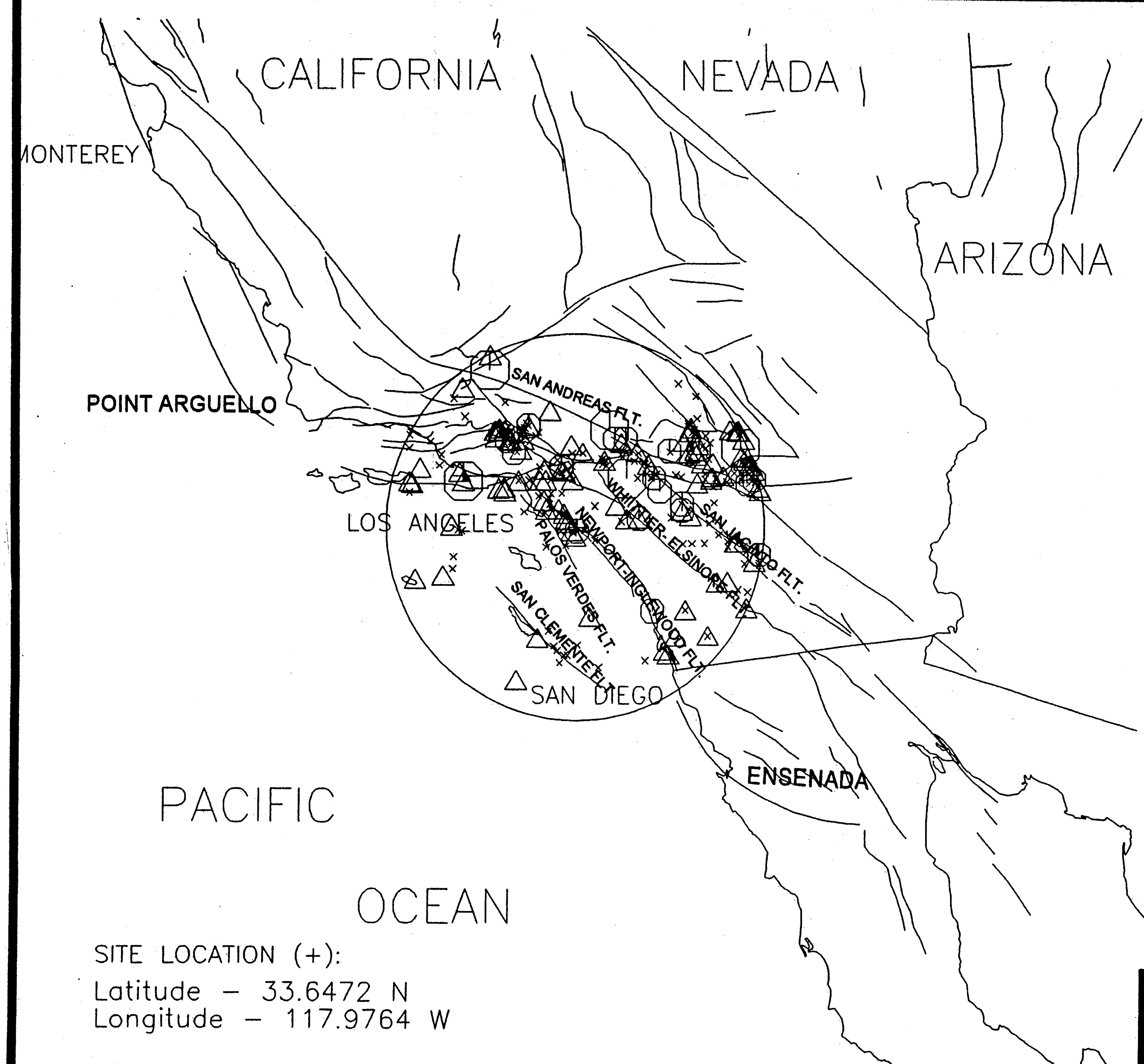
LOCAL FAULT MAP

PRELIMINARY SEISMIC ASSESSMENT
ORANGE COUNTY DESALINATION PROJECT
HUNGTINGTON BEACH, CALIFORNIA

GeoLogic Associates
Geologists, Hydrogeologists, and Engineers

DRAWN BY:	DATE:	JOB NO.
VL	AUGUST 2002	2002-050

INTENTIONALLY LEFT BLANK



HISTORICAL EARTHQUAKES 1800 TO 1999

FROM BLAKE (1999)

FIGURE 3

REGIONAL FAULTS AND HISTORIC SEISMICITY

PRILIMINARY SEISMIC ASSESSMENT
ORANGE COUNTY DESALINATION PROJECT
HUNTINGTON BEACH, CALIFORNIA

GeoLogic Associates
Geologists, Hydrogeologists, and Engineers

DRAWN BY:	DATE:	JOB NO.
JNM	AUGUST, 2002	2002-050

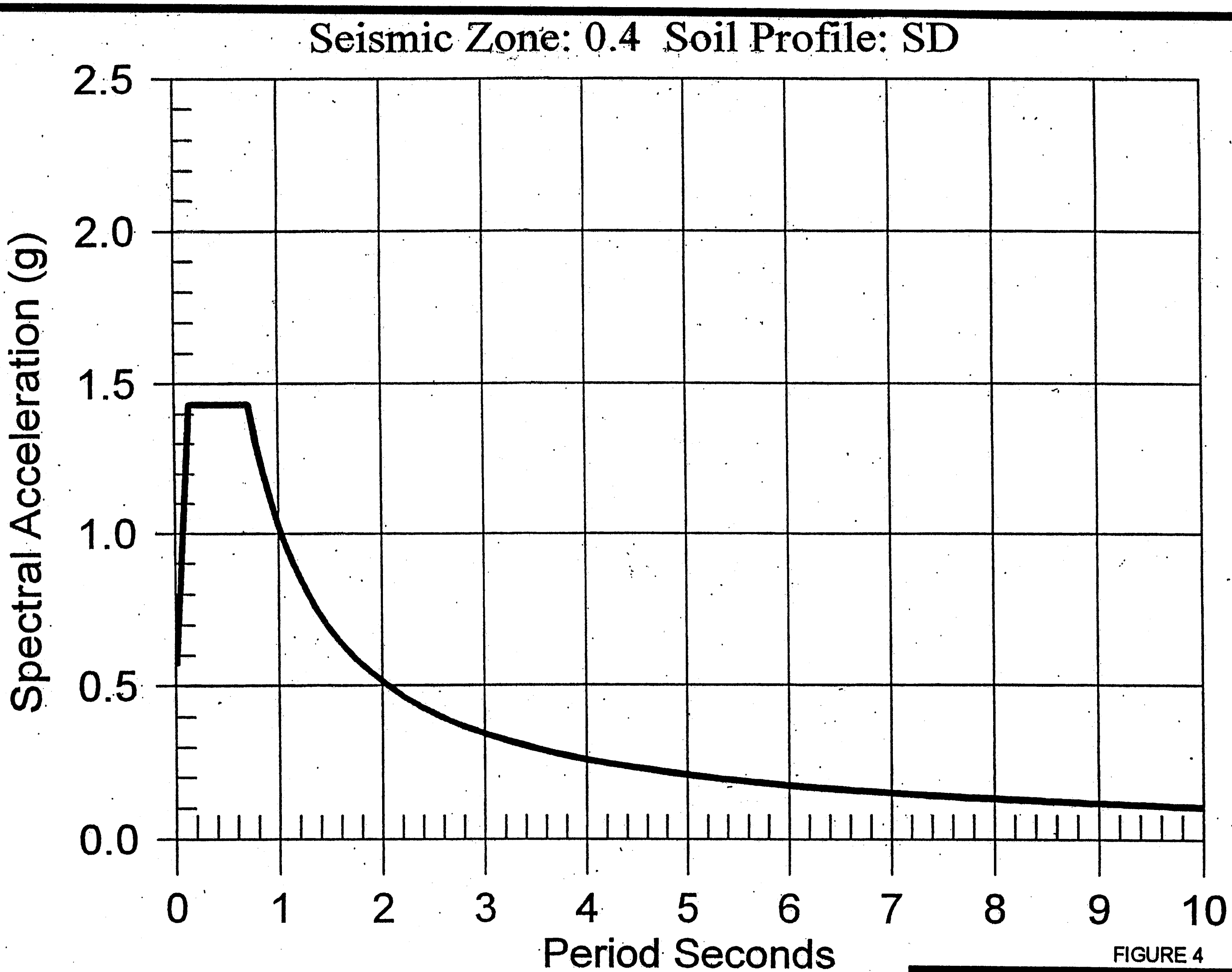


FIGURE 4

UBC DESIGN RESPONSE SPECTRUM

PRILIMINARY SESISMIC ASSESSMENT
ORANGE COUNTY DESALINATION PROJECT
HUNTINGTON BEACH, CALIFORNIA

GeoLogic Associates
Geologists, Hydrogeologists, and Engineers

DRAWN BY:	DATE:	JOB NO.
JNM	AUGUST, 2002	2002-050

The technical appendices to the Draft Preliminary Seismic Assessment, Orange County Desalination Project are available for review at the City of Huntington Beach Planning Department, 2000 Main Street, Huntington Beach, CA, 92648.

INTENTIONALLY LEFT BLANK